DOCUMENT RESUME

ED 232 892 SO 014 515

AUTHOR Carswell, Ronald J. B.; And Others
TITLE Children's Recognition of Rural Features from Anaglyphic Representations of Vertical Aerial Photographs.
INSTITUTION Calgary Univ. (Alberta). Faculty of Education.
PUB DATE 82
NOTE 21p.; Print marginally legible. Reprint from: Waters, N. M., Ed., Aspects of Human Geography: The Kelowna Papers. Vancouver, Tantalus Press, 1982. B.C. Geographical Series Number 34.
PUB TYPE Information Analyses (070)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Cognitive Ability; Educational Research; Elementary Education; Geographic Concepts; *Geography Instruction; Junior High Schools; Learning Theories; *Perceptual Development; *Photographs; *Spatial Ability; *Three Dimensional Aids; *Visualizat on
IDENTIFIERS *Anaglyphs; Canada; New Zealand

ABSTRACT

Three-dimensional (3-D) aerial photographs viewed with cardboard filter glasses (anaglyphs) aid elementary and junior high school students in recognizing physical features, offer a realistic vertical perspective, and have motivational values. A review of research on cognition, perception, and the use of anaglyphs reveals that pictures are an essential part of the perceptual substance from which children's images are constructed. Researchers have suggested that imagery and propositional thinking work simultaneously to generate effective thinking. Further, two studies of student's recognition of features on anaglyphs suggest that this type of photograph allows students to construct, store, and use 3-D imagery when it is needed in geographic thinking. The authors (1979) interviewed 60 elementary urban Canadian students (20 in each of grades 4, 5, and 6) using an anaglyph of a small town in West Germany. Ninety percent responded accurately to questions requiring the correct recognition of relief and 100 percent indicated recognition of the 3-D quality of the photograph. A 1980 study of students in grades 2, 5, and 8 using the same anaglyph preceded by a 2-D aerial photograph of the same scene found that the total number of accurate recognitions improved with use of the anaglyph. (KC)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

BEST COPY AVAILABLE

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☐ This document has been reproduced as received from the person or organization originating it.
X Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Walter G. Hardwick; Carswell
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

ED232892

CHILDREN'S RECOGNITION OF RURAL FEATURES FROM ANAGLYPHIC REPRESENTATIONS OF VERTICAL AERIAL PHOTOGRAPHS *

Ronald J.B. Carswell, The University of Calgary
Gary J.A. de Leeuw, The University of Calgary
John F. Early, Calgary Separate School System

* reprint from: Waters, N.M. (ed.),
Aspects of Human Geography: The Kelowna Papers,
B.C. Geographical Series #34, Vancouver,
Tantalus Press, 1982.

The University of Calgary
Faculty of Education
Department of Curriculum and Instruction
Calgary, Alberta T2N 1N4
Canada
(403) 284-5639

Sol 014515

CHILDREN'S RECOGNITION OF RURAL FEATURES FROM ANAGLYPHIC REPRESENTATIONS OF VERTICAL AERIAL PHOTOGRAPHS

Ronald J. B. Carswell, The University of Calgary
Gary J. A. de Leeuw, The University of Calgary
John F. Early, Calgary Separate School System

INTRODUCTION

Recent involvement in the preparation of junior atlases (Carswell et al., 1981) has led the authors of this paper to explore the feasibility of using anaglyphs with children as a means of representing the third dimension in aerial photography. In order to investigate the use of anaglyphs with children we have reviewed the relevant literature and conducted studies with students in elementary and junior high schools (de Leeuw and Carswell, 1979; Early, 1980). In this paper we state our assumptions, review the research, recommend several uses for anaglyphs in children's studies in geography, and discuss the approach that we have adopted to do task-oriented research with children.

Why seek to use three-dimensional (3-D) aerial photographs (stereograms or anaglyphs) to teach geography to children? In particular, we will suggest that anaglyphs might be used with children to serve at least three purposes: first, to represent the relief of physical features when it is deemed an important consideration in teaching a skill or concept; second, to present a realistic basis for the interpretation of contour lines and other symbols in topographic maps; third, to stimulate student interest in the study of particular places.

ANAGLYPHS, STEREOGRAMS, AND ELEMENTARY SCHOOLS

Anaglyphs are based on the use of two slightly offset retinal images, each available to one eye only, to stimulate the binocular disparity of normal vision. In most anaglyphs, the two images are superimposed on one print in complementary colours (usually red and green). When the print is seen through a viewer having filters of the same two colours a single 3-D image is obtained. Both the anaglyphs and the filter glasses used with them are relatively inexpensive to produce and the 3-D effect is rather easily seen by most viewers. Ordinary stereopairs may be used to produce anaglyphs.

Certainly, stereopairs used with stereoviewers create the same 3-D effect as anaglyphs and, when used by experienced observers, they provide images of high quality and considerable flexibility in the selection of areas to be viewed. The long history of human fascination with stereophotography is impressive, ranging in time from the 1850s to the present. During this time stereograms have achieved much wider use than anaglyphs. More than 130 years of commercial and recreational applications of stereograms have established their motivational and practical value. However, based on the authors' experiences in using stereograms

with children in the elementary schools we have found that many 6-to-12-year olds find the successful manipulation of stereopairs and stereoviewers to be impossible or very difficult to achieve.

Despite our past efforts to promote the use of stereograms, we found to our surprise that many teachers considered the inconvenience, time consumption, and costs of stereoviewers to be prohibitive. Consequently, stereograms were found in very few of the elementary schools visited by the writers. Thus, although stereograms are used in some Canadian secondary schools and many university classes in geography, we concluded that they are not well suited for widespread use with younger children and their teachers.

Because anaglyphs are used with inexpensive and easily replaced cardboard glasses, and because the use of these glasses offers very little difficulty to adult viewers with normal eyesight, we speculated that they might be more suitable than stereopairs for use with younger students. Additionally, anaglyph glasses can conveniently be provided by inserting them in small paper pockets glued to the back covers of school books.

ADULT VIEWING OF ANAGLYPHS

Our review of the relevant literature revealed that remarkably little has been published concerning the responses of viewers to anaglyphs. Some evidence is available on the ability of adults to view anaglyphs stereoscopically through the results of a questionnaire survey conducted by Adams (1970, 1969) in the Geographical Magazine. Readers were invited to respond to three anaglyphs, two of which were contour maps and the other an outline drawing of a cube. The majority of the respondents reported obtaining a satisfactory visual effect of depth although those who did not varied from 10% to 19%. Respondents also commented that the stereoscopic effect was not immediate but required from a few seconds to 10 minutes or more to develop.

One of the few reported studies exploring the effectiveness of anaglyphic viewing of aerial photographs was that of Dutton (1978) who investigated the use of anaglyphs as an aid to adult understanding of land forms. Dutton found that the experimental group, using maps and anaglyphic models, performed significantly better than the control group using maps only. In addition, the experience of viewing anaglyphic maps contributed positively to the ability to visualize and interpret contour maps in general.

ASSUMPTIONS UNDERLYING REVIEW OF RESEARCH

The only available research directly related to the ability of students to interpret anaglyphic representations of aerial photographs is reported elsewhere in papers by the writers (Early, 1980; de Leeuw and Carswell, 1979; Carswell and de Leeuw, 1978). In this research we were concerned primarily with the ability of students to recognize and label features on anaglyphs. Further, the instructional setting did not represent normal classroom behaviour; we interviewed children individually and

restricted our interactions with them to questioning and to "isolating" or "pointing" on the anaglyphs to direct their perceptions.

In developing and reporting these studies, we attempted to provide some initial information related to children's ability to recognize features on anaglyphs. Our findings could then be used to prepare visual learning resources that could help teachers to influence the learning processes of students. Our results must be related to perceptual and cognitive theories that will help in understanding how students will represent, retain, and apply visual information. If we are able to explain how a particular sequence of learning occurs in relation to explicitly described learning resources, teacher behaviours, and student behaviours, we are likely to make progress in helping teachers to control learning. [See Winn (1982) for a more complete discussion of this view of research and its implications for the development of learning strategies.]

VISUAL RECOGNITION, PERCEPTION, AND COGNITION

We must be aware of the mechanisms that underly recognition and labelling of features. Theories that integrate cognitive and perceptual processes are useful for the planning of instructional materials and systems. The visual recognition of such features as mountains or houses is generally explained as a process in which the perceptual act of seeing is linked closely to the cognitive acts of categorizing and naming. Perception and cognition are integrated in such a way that the sensory data are not just registered as a reflection of the objective characteristics of a 3-D illusion of the landscape, but rather are actively interpreted in terms of the visual and verbal constructs of the viewer. From a perceptual perspective such views are often called "constructivistic" (Norberg, 1978) and have been elaborated by such theorists and researchers as Neisser (1976), Gyr (1972), and Gregory (1970). From a cognitive standpoint these views of perception fit a philosophical and empirical framework extensively elaborated by Piaget (1969) and Bruner (1966) and their associates during the 1950s and 1960s. In terms of more recent work, a constructivistic view of recognition is generally consistent with the theory of such cognitive researchers as Kosslyn and Jolicoeur (1980) and Paivio (1971).

Thus, it is appropriate to consider visual recognition as a two-stage process (Mandler, 1980; Potter, 1966) in which the stages are interactive or partly integrated. The learner, firstly, engages in a preliminary organization of the sensory data (perception), and, secondly, matches the organized percept with categories in memory (cognition). The perceptual step is significant in that its processes follow a developmental sequence, and instruction should be tailored to meet particular developmental needs. The cognitive step in recognition also holds rich implications for the instruction of children.

Two explanations of the internal mechanisms of cognition are relevant to the development of visual resources: theories of imagery postulate "picture-like" internalized processes; theories of propositional thinking suggest a "language-like" format for the storage and representation of information.

When imagery is employed in thought, picture-like representations are generated in the "mind's eye" from more abstract representations stored in memory. Once images are formed they can be operated upon in a variety of ways to play an important role in thinking. Internally constructed images of the kind one uses in active thought draw upon one's "image-memories" of active perceptions, but may also be developed in a manner that is independent of directly perceived experience (Kosslyn, 1981, 1980; Kosslyn and Jolicoeur, 1980). Internal imagery also forms the basis of visual recognition of features when perceptually derived images are compared with memory images in an amazingly effective process that is usually subconscious and nearly instantaneous in its manner of operation (Paivio, 1971).

Language-like propositions also play a crucial role in thinking. In propositional thinking information is stored in discursive form in long-term memory, and used as the "substance" of logical deliberation. Propositional representations are similar to language in that they code and process information in discrete units of meaning linked in linear and sequential patterns governed by "syntax-like" rules (Pylyshyn, 1981, 1975, 1973; Anderson and Bower, 1973; Clark and Chase, 1972).

Although many propositionalist accounts claim a more fundamental role for propositional thinking than for imagery in terms of its relationship to memory and abstract thinking, other researchers have documented convincing accounts of imagery and propositional thinking working simultaneously and cooperatively to generate effective thinking (Kosslyn, 1981; Paivio, 1976; Chomsky, 1968). These accounts are very helpful in explaining and predicting the behaviour of children.

VISUAL RECOGNITION AND CHILD DEVELOPMENT

The ability of children to recognize increasingly more complex features in visual displays improves with age. However, the limitations that very young children experience in making recognitions do not appear to be narrowly perceptual (infants register what adults register visually and have a very early capacity to structure sensations so that features are recognized), but rather are more closely related to gradual development of more complex perceptual capacities (Bower, 1977; Haber and Hershenson, 1973). Very young children inspect visual displays in a single glance and are predisposed to identify those features that are centrally located, dominant in size, or most vivid in terms of colour or brightness. As children mature visually they become increasingly more skilled in attending to complex visual resources, perceiving more broadly and flexibly through successive, purposeful glances. Additionally, older children are more capable of perceptually structuring patterns of visual stimuli that are subtly presented, peripherally located, and complexly displayed (Mackworth and Bruner, 1970; Bruner, 1973, Piaget, 1956, 1969).

Developmental growth in the visual recognition skills of children can also be explained in cognitive terms. When younger and older children are confronted, the former possess a less flexible and less objective capacity to generate the images and propositions necessary for complex recognitions. For example, they are less capable of using imagery to

consider spatial arrangements of features from perspectives not immediately perceived (Piaget and Inhelder, 1956); they are more likely to distort reality by imposing their personal image upon visual information (Potter, 1966); and they are less capable of using the imaginal and propositional skills needed to analyze the scales or perspectives of pictures (Piaget, Inhelder, and Szeminska, 1960).

CHILDREN'S RECOGNITION OF FEATURES ON AERIAL PHOTOGRAPHS: IS THE THIRD DIMENSION REALLY NECESSARY?

Is there evidence in the literature that suggests children are likely to benefit from the addition of the third dimension? In order to explore this issue, we ask two related questions in this section relevant to the viewing of aerial photography: What role does the third dimension play in the general recognition of features? Does the research that is concerned with children's recognitions on 2-D photographs imply that significant features of the sort that might be identified with 3-D viewing are not recognized?

As Vernon (1976) has pointed out, adults take advantage of both monocular and binocular cues in judging distance. In perceiving depth it would appear that monocular cues provide qualitative information such as interposition or overlap, but the magnitude of depth is obtained binocularly (Kaufman, 1974). It would seem that both types of cues complement each other to make depth perception more precise. Gibson (1969) reported a study which showed the superiority of adults in estimating distance and making size judgements; young children tend to underestimate both. There is some evidence that binocular disparity, when combined with monocular cues, results in increased acuity (Kaufman, 1979). Binocular cues are not available in 2-D pictures; thus, the viewer must rely on monocular cues.

Oh (1969) found a developmental progression in children's ability to use the cues of overlap, size perspective, linear perspective, and aerial perspective in pictures; all four were in evidence by age nine.

In vertical, aerial photographs, not only are binocular cues absent but monocular cues are limited as well. Because of their particular perspective, depth or distance cues in these pictures are restricted to light and shade. Relative size may also assist visual discrimination, provided that the viewer is able to capitalize on past experience with objects of the same class. The ability of children to read and interpret vertical, aerial photographs was investigated by Kingston (1969), Dueck (1969), and Barnett (1969) using photographs ranging in scale from 1:6000 to 1:31,800. These investigators found that students in Grades 1 through 9 were able to read aerial photographs although their ability to interpret them was very seriously limited for the three lowest grades. Five- to nine-year-olds tended to become perceptually hooked on the more centrally located and visually obvious details. Often they fixated on unimportant visual features, and once an incorrect line of visual recognitions was started--even when strong contrary visual evidence was examined--many found it difficult to switch. Few students identified evidence of any relationships from features widely dispersed across the photographs. Nearly all identified individual rather than grouped features and very

few were able to switch from a personal perspective to imagine other viewpoints within the area of the photograph. Interestingly, students made very few recognitions of relief in the photographs, and features were not described as to height. Nevertheless, even the five-year-olds made an impressive number of identifications of individual features and nearly all displayed comprehension of the general nature of an aerial photograph as a very small representation of a very large place viewed from above.

A greater proportion of students in Grades 4 to 9, however, were able to use the monocular cues on aerial photos to integrate parts of the picture into a unified whole. They were also better able to hypothesize using clues in the photograph; younger children appeared to rely on personal imagery to support their recognitions. Significantly more difficulty was experienced with complex pictures in which features were unclear or ambiguous; and children experienced considerable trouble making identifications that depended upon inferring relationships among widely separated, complex, or varied patterns of sensory data. With the smallest scale photography, the tendency was for Grade 4 students to identify features by shape and form instead of by size. With this type of photograph, failure to recognize scale effects caused the majority of recognition errors. References to changes in elevation or the height of individual features were not common, even with the older students.

In general, these results are consistent with the conclusions of others who have studied children's responses to aerial photographs and other relatively complex pictures of places (Carswell, 1978; Jahoda et al., 1977; Downs and Stea, 1973; de Leeuw, 1972; Blaut and Stea, 1971; Dale, 1971; Long, 1961, 1953). Overall, the research on children's responses to aerial photos and other complex geographical pictures does not suggest whether or not the addition of the illusion of 3-D to these photographs would have resulted in a significantly greater number of recognitions of important features or relationships. The limitations in the quality of children's recognitions seem quite reasonably explained in developmental terms without reference to the third dimension. Admittedly, it is interesting that so few references to elevation were reported, although this could have been an artifact of the research questions in the studies reviewed.

A PRELIMINARY STUDY OF CHILDREN'S FEATURAL RECOGNITION ON ANAGLYPHS

In 1978, Carswell and de Leeuw (1979) used a clinical interview strategy to investigate the responses of 60 urban Canadian children (20 in each of Grades 4, 5, and 6) to the viewing of an outstandingly sharp and dramatic anaglyph of a small town surrounded by an upland farming area in West Germany (Zeiss, 1973). The interviewers followed a prearranged sequence of 16 questions or directions. Interviews lasted from 10 to 15 minutes each. The following are representative items from the questionnaire:

Undirected item

- What are the things that you see? Is there anything else?

Directed items

- Use the pointer to indicate three high places.
- Use this pointer (interviewer hands small pointer to child); run it up and down three of the steep places.
- What is this? (interviewer uses pointer to touch a representation of a road). What would you call this thin line?
- What is this? (interviewer indicates the small town). What would you call this area?
- How might people in this area make a living?

A careful record was made of all student responses. For example, children were asked to point to all features located in the undirected questioning sequence and all identifications were recorded on a map of the area.

In reporting this study, de Leeuw and Carswell (1979) noted the somewhat surprising finding that all subjects appeared to be capable of perceiving the third dimension. It was later concluded, however, that at least two students may not have perceived the binocular effect. Instead, these students may have used monocular cues to convince the interviewers that a 3-D illusion was perceived.

The evidence of successful recognitions of the gross aspects of relief in the anaglyph was the most impressive finding, particularly when it is noted that this was achieved with less than 60 seconds of instruction in the use of the glasses and anaglyph print. Spontaneous comments and responses to "undirected" questions indicated a strong initial awareness of relief; 100% of first comments and 92% of second comments related to the major 3-D aspects of the anaglyph. Ninety percent of the children responded accurately to seven "directed" questions requiring correct recognition of relief, and 100% indicated recognition of the 3-D in at least a portion of their responses.

A second important finding was that, by the end of the interviews 90% of the students recognized the anaglyph to be a representation of a real place. Of course, as the interviews progressed, a succession of clues suggesting the general frame of reference of the anaglyph was contained in the wording of the questions. Nevertheless, with such a minimal degree of facilitation, all of these students were able to operate independently to recognize correctly one or more features on the anaglyph.

Consistently recognized features were few in number; however, although at least 30 detailed features were recognized correctly, a scant two (trees, roads) were consistently identified by more than 50% of the total sample of students. However, when roughly synonymous terms were equated, six broad categories of features emerged as most often recognized: major physical features of high or low relief (98%), transportation routes (75%), specific places of habitation (70%), urban settlement (53%), drainage features (40%), and forest cover (32%).

A very high ratio of errors to correct recognition was revealed: 50% for Grade 4 and 37% for both Grades 5 and 6. Interestingly, this was the only finding to indicate that Grade 4 students (8-to-9-year olds)

achieved significantly less success in recognitions than did Grade 5 and 6 students (10-to-12-year olds).

The high proportion of errors made by Grade 4 students may be explained in the following ways. The effect of vertical exaggeration in the anaglyphs seemed to figure prominently; features located on slopes (e.g., streams, fields, roads, orchards) were often correctly recognized as a result of first impressions but were misidentified when the distorted illusion of relief was duly considered.

Approximately 15% of the students initially interpreted the anaglyph in terms of the most obvious and literal sensory qualities of 3-D: relative size, shape, and texture. The most radical level of such misinterpretations involved initial references (by 10% of the sample) to wholly surficial qualities--such as lumps, little dots, flat things, ups and downs, and neat designs. A similar type of misidentification was further complicated by the inability of about 20% of the students to maintain a constant scale across the anaglyph. Several of these students correctly perceived such features on the anaglyph as houses and roads; but the same students also recognized trees as moss, hills as bumps, and orchards as marching bands. In one extreme instance, an angular field was misidentified as the outline of the province of Alberta. Interestingly, about 60% of both types of responses occurred among Grade 4 children.

Most errors in identification occurred during the directed phase of questioning. In this phase students were pushed to examine unfamiliar representations, or to seek inferences from scanty or incomplete sensory data. Students revealed little potential to make such complex recognitions as "farming area" or "forestry area," although farm buildings were recognized by 9% of the sample, orchards by 24%, and forests by 36%.

Overall, this study revealed relatively little difference between the quality of identifications made by children ranging in age from nine to twelve years. Errors were reduced with age, and there was some indication of the older students being more skilled in implying recognitions from complex data and using a more consistent and accurate frame of reference for the recognition of features.

The affective responses of the children encouraged the researchers to continue to investigate the potential of anaglyphs for use with children. Students reacted with considerable enthusiasm, indicating an interest in using anaglyphs to find information. Their comments revealed a fascination with the 3-D landscape which sometimes involved imagination and fantasy.

A SECOND STUDY OF CHILDREN'S FEATURAL RECOGNITION ON ANAGLYPHS

In 1980, Early conducted a study that adapted and extended the work of de Leeuw and Carswell (1979). In Early's study, a sample of 60 subjects was randomly selected from classes in three New Zealand schools located in urban and suburban areas. The subjects were drawn from Grades 2, 5, and 8, with an equal number of males and females from each grade.

The questionnaire and data-recording strategies used in this research were much like those of the preceding study and the West German landscape examined by the children was the same. However, the subjects responded to the questionnaire twice; first, while viewing a 2-D aerial photograph depicting the scene and, second, while viewing an anaglyph of the same scene. The major anticipated outcome was that the addition of the third dimension would improve recognition.

When the responses of the children in the preceding study were compared with those in the Early study, it was clear that all of the major findings were consistent; for example, a similarly high proportion of students achieved 3-D viewing; recognition of the gross aspects of relief dominated responses to undirected questions; all but a very small proportion of the subjects recognized the anaglyph as an aerial landscape; and percentages of incorrect identifications were similarly high for younger students.

In general, the Grade 5 students in Early's study demonstrated a higher degree of success in directed recognitions of certain features than did the Grade 5s in the preceding study (of seven most accurate recognitions in both studies, the New Zealand students were correct about 46% of the time, while the Canadian students scored 35%). However, it should be remembered that, in Early's study, interpretation of the anaglyph followed a directed examination of the 2-D photograph.

The Early study extended the previous findings in providing for comparisons between children's interpretations of 2-D and anaglyphic aerial views, as well as by widening the age range of the sample.

In a comparison of the findings from anaglyphs and 2-D photographs, Early found that the total number of accurate recognitions improved when the anaglyph was being used. However, the total for inaccurate recognitions also increased to such an extent that ratios of correct to incorrect identifications remained about the same as in the regular aerial photographs. Furthermore, the general improvement in recognitions when the anaglyph was viewed was almost entirely restricted to the recognition of physical features; cultural recognitions were not enhanced.

Children in Grades 2 and 5 were more successful in recognizing relief on the anaglyph than on the aerial photograph. However, Grade 8 students were able to make such effective use of the monocular cues on the 2-D representation that they were almost as accomplished in identifying relief in this mode as on the anaglyph.

Comparisons between the two modes of representation underline the problems of vertical exaggeration on the anaglyph. Features distorted by the effects of vertical exaggeration were isolated, and student recognitions of these features on the anaglyph and aerial photograph were contrasted. Results indicated that students were less successful in making such recognitions on the anaglyph. Additionally, somewhat to our surprise, we found that Grade 8 students were much more likely to make those errors than were students in Grade 4.

Early found several other ways in which age was related to ability

to recognize features on anaglyphs. Total successful recognitions increased with age and school grade. It seemed that the major relief features were so successfully recognized by Grade 2 students that Grade 8s could not improve upon this performance. The proportion of errors to correct recognitions grew smaller with age and grade level. The latter was accomplished by an increase in totals of correct recognitions sufficient to compensate for increased errors due to the effects of vertical exaggeration.

Finally, Early made a more thorough examination of the ability of students to make inferences concerning relationships than did de Leeuw and Carswell. Not surprisingly, he found that the older students made more identifications requiring integration of disparate, scattered, and incomplete sensory cues. Significantly, he concluded that students viewing anaglyphs in Grades 2, 5, and 8 identified more relationships between field perceptions (the setting of an image such as a plateau, valley, or slope) and figure perceptions (a discrete image such as a building or road) than when 2-D photographs were viewed.

SOME RECOMMENDATIONS FOR THE USE OF ANAGLYPHS WITH SCHOOL CHILDREN

Is it both desirable and feasible to use anaglyphic aerial photographs with school children? The question of desirability can be clarified by briefly reviewing the potential for geographic learning of three things: realistic pictures, aerial photography, and anaglyphs. The question of feasibility can be partly answered by the studies reviewed in this paper. The issue of whether or not it is important to use realistic pictures with children must ultimately be resolved with reference to the ways in which children represent and use information. We believe that recent research into the role of imagery in thinking presents strong arguments for the use of a pictorial or depictive format in the teaching of geography. When one is trying to represent spatial information to children, or to help children to solve spatial problems, it is likely that the pictorial format is the optimal way to present much--but not necessarily all--of that information. Often pictures, diagrams, maps, and charts are an essential part of the perceptual substance from which children's images are to be constructed. Since it seems very likely that much of children's thinking about certain types of spatial problems is done with internal imagery, they must be helped to perceive external images and act upon them to develop accurate, internalized representation in memory. Finally, one must decide how these "image memories" are likely to be used in geographic thinking. As Kosslyn (1980:473) has suggested, it may turn out that the ways in which learners should be taught information depend on the use to which it will be put later.

Why use vertical, aerial photographs with children? Of course, the answer to this question lies in a consideration of the scale and perspective of aerial views. Such photographs should enable children to examine the structural relationships of objects, which, in everyday experience, are separate. In terms of imagery, aerial views should provide part of the perceptual substance from which images of representative places and relationships are constructed, remembered, and used in thinking.

Why use anaglyphs with children? Clearly, anaglyphs should help students to perceive the importance of relief in particular settings. In other words, anaglyphs should be used to instruct children so that they will perceive, construct, store, and use 3-D imagery when it is needed in geographic thinking.

But is it feasible to use aerial photographs and anaglyphs to achieve these things with children? The answer to this question seems to be in the affirmative when considered solely from the perceptual point of view. As we noted in previous references to perception, school children should be able to register complex visual patterns, even though earlier limitations in the capacity to see inconspicuous or peripheral data, or to scan pictures in a purposeful way, may persist with some school children. Furthermore, our studies with children suggest that such perceptual limitations are fairly common among children in elementary school when anaglyphs are perceived.

The literature on cognitive learning and our own studies, however, have led us to believe that whatever inadequacies children experience in the interpretation of anaglyphs are more likely to be cognitive than perceptual. Although the children that we interviewed tended to stress visually prominent and centrally located features in indirect viewing, when specific features were isolated by the interviewer, students often made conceptual errors; that is, they lacked either the imagery, or the verbal cues, that would permit them to recognize more than a few of the features represented on the anaglyph. Errors were commonplace among the youngest children, and most can be explained in terms of the inappropriate frame of reference of the viewer. Children in both studies (Early, 1980; de Leeuw and Carswell, 1979) reorganized unfamiliar, sketchy, and vertically exaggerated sensory data to construct highly personalized images. One of the most dramatic examples of this involved interpretation of the orchard: it was imagined as a marching band (see page 8), a group of soldiers gathered for inspection, a wheat field, and a parking lot filled with cars.

As has been the case in most other studies referred to in this paper, our key premise has been that the mind organizes data according to images or propositions that have evolved out of previous interactions with the environment. The pattern of looking is partly dependent on the model that the viewer adopts. If an inappropriate model is adopted, the sensory input will be organized to conform with the model, and the viewer will misinterpret information from the visual field. Thus, an important question of feasibility is raised: does the incidence of young children's inappropriate recognitions imply that we should not use anaglyphs with them? Can it be claimed that younger students lack the experience or cognitive skills needed to construct the mental models to make sufficient sense of anaglyphs?

If children's cognitive capacity needed for relatively simple recognitions on anaglyphs can be questioned, what of their ability to infer relationships? At a first glance, the evidence of younger students implying valid relationships between features on anaglyphs is not encouraging. Early (1980) found that, although anaglyphs helped students to see relationships between relief and cultural features, often vertical

exaggerations led to mistaken conclusions. As reported elsewhere in this paper, the writers and others have shown that children find it more difficult to see relationships than to recognize individual features on aerial photographs. Clearly, if we are to justify their use in terms of geography teaching we must be able to demonstrate that children can use anaglyphs to infer some types of relationships. Virtually all important concepts and generalizations in geography deal with spatial relationships in some way. Do young school children lack the mental models or the skills required to infer meaningful spatial relationships in photographs on anaglyphs?

Our answers to the preceding questions are based upon two assumptions. The limitations that we have identified are not developmental absolutes, nor do they indicate the full potentialities of children's capacity to learn when instructed.

Although developmental psychologists such as Jean Piaget and Jerome Bruner have demonstrated that the thinking of younger school children is limited in certain functional ways (see page 5 of this paper), none of these limitations seem likely to inhibit children from learning to recognize important features or to imply simple spatial relationships on anaglyphs. Furthermore, we suggest, it is often the case that children lack only two things from which the necessary mental models and skills can be constructed: first, experience with analogous visual things; second, opportunities to learn through practice to apply mental models to unfamiliar visual representations.

Our studies have demonstrated that anaglyphs have instructional potential. That is, when inappropriate visual experiences and visual applications are provided, children are unlikely to generate the imagery and the skills needed to use anaglyphs. Examples of errors or shortcomings in discovering relationships should not be permitted to overshadow the accomplishments of children in viewing the anaglyph. Nearly all of the students, with no formal instruction, accomplished several key things: recognition of the true content of the anaglyph; identification of several features; discovery of the illusion of 3-D. Early (1980) showed that children found anaglyphs less difficult than photographs to interpret and, in his as well as the de Leeuw/Carswell (1979) study, children demonstrated enthusiasm for the experience of viewing the anaglyph.

A further indication of the likelihood of children learning more effectively how to interpret anaglyphs when instructed lies in the effect of our clinical interviewing strategy of the subjects in both studies (see page 7 of this paper). As questioning progressed with the children, all but a few of the youngest were able to discard an inappropriate frame of reference as a result of prolonged and directed examination of the anaglyph. Additionally, although we have not conducted formal studies to assess the effects of instruction upon children's interpretations of anaglyphs, we have participated in the field testing of Thinking About Ontario (Carswell et al., 1981), an atlas for elementary school children. This atlas contains several anaglyphs which, in evaluation sessions, teachers rated highly as motivational and instructional tools.

Possibilities for instruction in children's relational thinking using aerial photographs are suggested in the work of Blaut and Stea (1969) and Muir and Blaut (1969). These researchers used aerial photographs with children in Grade 1, encouraging them to employ much enlarged aerial photographs in various ways to engage in playful and imaginative activities. They found that these children soon learned to express realistic relationships in their play and concluded that opportunities for prolonged and spontaneous play using aerial photographs could lead to the comprehension of concepts of geographic significance. Although these findings were for 2-D representations they hold implications for the development of instructional strategies for anaglyphs.

Accordingly, we recommend that anaglyphs be included in school texts and other geographical resources. In particular, we suggest that they be used with younger students (ages 6 to 12), although we see some possible uses with older students as well.

Especially for younger students, anaglyphs have a broad justification. Because well prepared anaglyphs can be dramatically realistic representations of cultural and physical landscapes they seem to hold the promise of helping to inspire children to an enthusiastic and contemplative interest in places. In the studies in which the writers participated, younger students displayed a fascination with the abundance of concrete detail in the rural anaglyphs they examined. It seemed to us that these children were interested in a careful and prolonged study of the anaglyphs we showed to them. It also seemed that their motivations were intrinsic. Perhaps some were fascinated with the aesthetic potential of the anaglyph, enjoying its dramatic relief, its richness of pattern, or its rhythms. Others became involved imaginatively, creating mythical "kingdoms" in the picture, and imagining the "powers of a giant." A few of the students seemed captured by more practical questions. Some sought to discover the occupations and lifestyles of the "real people" living in the rural landscape. Such responses by children are not inconsequential because they cannot easily be categorized or related to systematic learning. We suspect that, in the long run, "flights of fancy" of this sort may often provide children with substance for such valuable concepts as "land use," "rural life-style," or "urban core." Furthermore, for children this kind of eminently practical experience may lead to a genuine interest and a creative involvement in geography. Although this aspect of anaglyphs or realistic pictures of any sort is relatively little understood in geographic education, we believe that it should be an important part of schooling.

For younger children in particular, every learning resource should be considered in terms of its possible contributions to the attitudes and skills that must be developed to foster learning in general. Vividly represented pictures and models are much used in the primary grades to help children to construct the imagery with which they will interpret verbal materials and express themselves in writing and drawing. Many teachers of the language arts have long believed that intellectual development in general--and verbal development in particular--can be fostered when children are encouraged to construct internal images and express them in writing. As we noted in the first part of this paper, theories in cognitive psychology (Kosslyn, 1981; Paivio, 1976; Chomsky, 1968) support this assumption. Convincing accounts have been developed

of imagery and propositional thinking working together to generate effective thinking. Anaglyphs should be used in concert with other pictorial resources to help children to express themselves imaginatively.

In a more restricted sense, primary school students should use anaglyphs together with 2-D aerial photographs to visualize their own neighbourhoods and communities. As Blaut and Stea (1969) and Muir and Blaut (1969) have demonstrated, aerial photographs can be used to stimulate relational thinking. Anaglyphs should be employed to introduce young students to the importance of relief and to foster recognition of features.

An optimum level at which to begin to use anaglyphs for systematic instruction in geographic skills and concepts is the upper elementary grades (ages 9 to 12). Early's (1980) work seems to indicate that 7 to 8-year-olds are too likely to read anaglyphs using inappropriate frames of reference or to focus too narrowly upon a few prominent features. The findings of Carswell and de Leeuw (1978) and Early (1980) established that most upper elementary students were able to read anaglyphs with sufficient facility to merit their use. For these students anaglyphs appear to aid in recognition of physical features, offer a realistic vertical perspective, and have motivational value. For children in general, anaglyphs might be carefully designed to serve two purposes at least.

First, anaglyphs should be selected carefully to depict settings in which the relief is impressive and tends to influence the pattern of settlement. Relief observed from the vertical vantage point in anaglyphs provides a holistic landscape perspective that students are unlikely to observe as clearly or dramatically by any other means used in schools. However, two cautions must be observed in preparing anaglyphs for this purpose. The anaglyph must be selected to obtain maximum clarity and ease of 3-D viewing. We have discovered in anaglyph production that a high degree of clarity or sharpness is not readily achieved. It appeared that even slightly blurry anaglyphs tend seriously to discourage teachers and children from using them. For these reasons we suggest that those who produce children's resources be very critical and selective in making anaglyphs. Only the sharpest should be published. Sharp originals with medium to high relief photographed at low to medium elevations often seem to work well. Furthermore, anaglyphs in which the vertical exaggeration significantly distorts the meaning of interactions between relief and land use might be accompanied by explanations and diagrams that show the degree of distortion. In some cases such anaglyphs might be paired with oblique photography of the same settings to provide instructive contrasts.

Second, anaglyphs can be paired with relief maps of identical areas to provide a concrete basis for understanding the meaning of symbols that depict relief. Robinson and Bartz-Petchenik (1976:54) have stressed the role of imagery in mapping. In their view, "the potential for image development is the most elegant attribute of the map." We suggest that, in some instances, anaglyphs be used to help children to generate realistic images of places depicted on maps. Through careful matching of the perceptual image of the anaglyph with that of the map, children might not only discover the character of maps as abstractions, but also develop the skill of generating realistic images of relief when comparable maps are viewed.

Carswell (1971) has demonstrated that students in the upper elementary grades can learn to use contour symbolization. Thus, it seems reasonable that when contour symbolization is being taught to children in these grades, anaglyphic contour models might be included to provide a transition between the relief map and the anaglyphic, aerial photograph. Here, several cautions seem appropriate. Clear anaglyphs are essential for this exercise. Relief maps must be very carefully aligned and trimmed to match the models. Additionally, the task of matching the anaglyph image with particular contours on maps may be difficult for children to perform. Research is needed on the workability of this strategy if it is to be used with young students.

For all of the above reasons, we are convinced that textbooks, junior atlases, and other geographical materials for children should provide abundant opportunities for the study of realistic pictures rich in geographical content. Because anaglyphs are a relatively inexpensive and easily used source of realism for younger students, they should be included as one of the many basic resources for the teaching of geography in the elementary schools.

REFERENCES CITED

Adams, J. M.
1970 "Anaglyphs analysed." Geographic Magazine 42 (February):386-387.

1969 "Mapping with a third dimension." Geographical Magazine 42 (October):45-49.

Anderson, J.R. and G. W. Bower
1973 Human Associative Memory. New York: V. H. Winston and Sons.

Barnett, D. C.
1969 "The efficiency with which children of grades seven, eight, and nine are able to read and interpret vertical aerial photographs." Calgary: The University of Calgary, unpublished Master's thesis.

Blaut, J. M. and D. Stea
1969 "Studies of geographic learning." Annals of the Association of American Geographers 61(2):387-393.

1969 Place Learning: A Place Perception Research Report, Number 4. Worchester, Mass.: Clarke University.

Bower, T. G. R.
1977 The Perceptual World of the Child. Cambridge, Mass.: Harvard University Press.

Bruner, J. S.
1973 Beyond the Information Given. New York: W. W. Norton.

1966 Studies in Cognitive Growth. New York: Wiley.

Carswell, R. J. B.
1978 "Using aerial photographs in the elementary and junior high grades: An exploratory study." Social Studies Review 17(2) (Winter):28-33.

1971 "Children's abilities in topographic map reading." In Henry W. Castner and Gerald McGrath (Eds.). Cartographica: Design and the Map User, Toronto: York University.

Carswell, R. J. B. and H. W. Castner, G. J. A. de Leeuw, and T. D. Mansfield
1981 Thinking About Ontario: A Hosford Study Atlas. Toronto and Edmonton: Hosford Publishing.

Carswell, R. J. B. and G. J. A. de Leeuw
1978 "Children's perceptions of anaglyphic prints of vertical aerial photographs: An exploratory study." Paper read at the International Geographic Union Conference, Ibadan, Nigeria, July, 1978.

Chomsky, N.
1968 Language and Mind. New York: Harcourt, Brace and World.

Clark, H. H. and W. G. Chase
1972 "On the process of comparing sentences against picture." Cognitive Psychology 3:472-517.

Dale, P. F.
1971 "Children's reactions to maps and aerial photographs." Area 3(3).

de Leeuw, G. J. A.
1972 "Experimental test and formative assessment of an instructional module for the preparation of elementary teachers." Austin: University of Texas, unpublished Doctoral dissertation.

de Leeuw, G. J. A. and R. J. B. Carswell
1979 "A practical way of simulating the third dimension in the earth sciences." Alberta Science Education Journal 18 (September):9-20.

Downs, R.M. and D. Stea (Eds.)
1973 Image and Environment: Cognitive Mapping and Spatial Behavior. Chicago: Aldine.

Dueck, K.G.
1969 "Reading and interpreting vertical aerial photographs in the intermediate grades." Calgary: The University of Calgary, unpublished Master's thesis.

Dutton, R.
1978 "The mediation of three-dimensional visualization for isolinal graphics." British Journal of Educational Technology 9 (October):211-216.

Early, J. F.
1980 "Students' perceptions of an anaglyph." Calgary: The University of Calgary, unpublished Master's thesis.

Gibson, E. J.
1969 Principles of Perceptual Learning. New York: Appleton-Century-Crofts.

Gregory, R. L.
1970 The Intelligent Eye. London: Weidenfeld.

Gyr, J. W.
1972 "Perception as reafference and related issues in cognition and epistemology." In J. R. Royce and W. W. Rozeboom (Eds.), The Psychology of Knowing. New York: Gordon and Breach.

Haber, R. N. and M. Hershenson
1973 The Psychology of Visual Perception, New York: Holt, Rinehart and Winston.

Jahoda, G., J. B. Deregowski, E. Ampene, and N. Williams
1977 "Pictorial recognition as an unlearned ability." In G. Butterworth (Ed.), The Child's Representation of the World. New York: Plenum Press.

Paivio, A.
1971 Imagery and Verbal Processes. New York: Holt, Rinehart and Winston.

Kaufmann, G.
1979 Visual Imagery and Its Relation to Problem Solving. Bergen: Universitetsforlaget.

1974 Sight and Mind: An Introduction to Visual Perception. New York: Oxford Press.

Kingston, E. E.
1969 "Reading and interpreting vertical aerial photographs in the primary grades." Calgary: The University of Calgary, unpublished Master's thesis.

Kosslyn, S. M.
1981 "The medium and the message in mental imagery: A theory." Psychological Review 88(1):46-66.

1980 Image and Mind. Cambridge, Mass: Harvard University Press.

Kosslyn, S. M. and P. Jolicoeur
1980 "A theory-based approach to the study of individual differences in mental imagery." In R. E. Snow, P. A. Frederica, and W. E. Montague (Eds.), Aptitude Learning and Instruction, Vol. 2. Hillsdale, N.J.; Erlbaum.

Long, M.
1961 "The reaction of grammar school pupils to geographical pictures." Geography 46:322-337.

1953 "Children's reaction to geographical pictures." Geography 38:100-107.

Mackworth, N. H. and J. S. Bruner
1970 "How adults and children search and recognize pictures." Human Development 13:149-177.

Mandler, G.
1980 "Recognizing: The judgement of previous occurrence," Psychological Review 87:252-271.

Muir, E. M. and J. M. Blaut
1969 "The use of aerial photographs in teaching mapping to children in the first grade: An experimental study." In David Stea (Ed.), Working Papers in Place Perceptions, Report No. 2. Worchester, Mass.: Clarke University.

Neisser, U.
1976 Cognition and Reality: Principles and Implications of Cognitive Psychology. San Francisco: W. H. Freeman.

Norberg, K.
1978 "Perception theory: Does it make any difference?" Journal of Educational Communication and Technology 26(1) (Spring):5-13.

Oh, C. Y.
1969 "A study of the development of children's ability to perceive depth in static two-dimensional pictures." (Doctoral dissertation, Indiana University, 1968). Dissertation Abstracts International, 1968, 29:3470B.

Paivio, A.
1976 "Images, propositions, and knowledge." In J. M. Nicholas (Ed.), Images, Perception and Knowledge. Dordrecht, The Netherlands: Reidel.

Piaget, J.
1969 The Mechanisms of Perception. New York: Basic Books.

Piaget, J. and B. Inhelder
1956 The Child's Conception of Space. London: Routledge and Kegan Paul.

Piaget, J., B. Inhelder, and A. Szeminska
1960 The Child's Conception of Geometry. New York: Basic Books.

Potter, M. C.
1956 "On perceptual recognition." In J. S. Bruner (Ed.), Studies in Cognitive Growth. New York: Wiley.

Pylyshyn, Z. W.
1981 "The imagery debate: Analogue media versus tacit knowledge." Psychological Review 88:16-45.

1975 "Do we need images and analogues?" In Proceedings of the Conference on Theoretical Issues in Natural Language Processing, MIT.

Pylyshyn, Z. W.
1973 "What the mind's eye tells the mind's brain: A critique of mental imagery." Psychological Bulletin 80:1-24.

Robinson, A. H. and B. Bartz-Petchenik
1976 The Nature of Maps. Chicago: University of Chicago Press.

Vernon, M. D.
1976 "Development of perception of form." In V. Hamilton and M. D. Vernon (Eds.), The Development of Cognitive Processes. London: Academic Press.

Winn, W.
1982 "Visualization in learning and instruction: A cognitive approach." Educational Communication and Technology: A Journal of Theory, Research, and Development. (February, in press.)

Zeiss, C.
1973 Double-Projector System, DP1, DP2, DP3. Oberkochen: Zeiss

N.B. All page references in this paper relate to this article and not to the journal page number.